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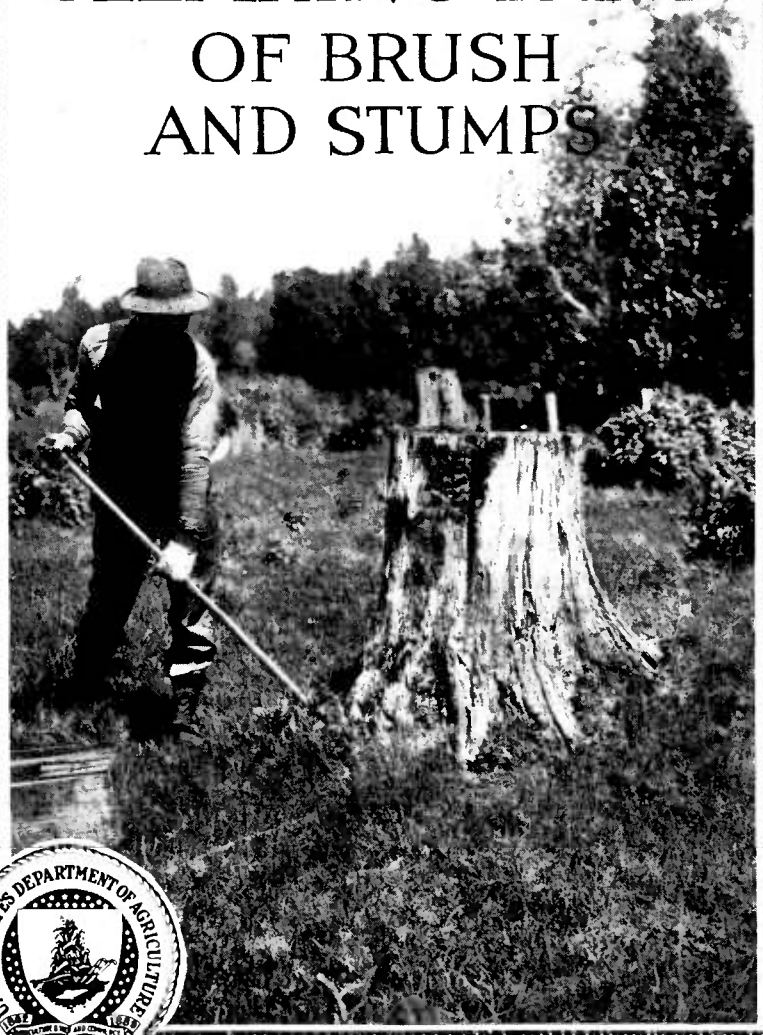
CLEARING LAND OF BRUSH AND STUMPS



ON MANY FARMS there are small tracts on which only brush or inferior timber is growing which would be more productive if cleared and devoted to the growing of cultivated crops. Also many cultivated fields still contain large stumps which impede farm operations and add to the cost of crop production.

The removal of brush, trees, and stumps and the preparation of the ground for crops are at best laborious tasks, but the labor in many cases can be greatly reduced if proper tools and methods are employed. The method which succeeds best under one set of conditions may be wholly unsuited to other conditions. This bulletin describes the methods followed in different localities and points out the conditions under which their use is warranted. It does not attempt to advocate one method as superior to any other, for each has been found satisfactory under the conditions to which it is adapted.

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CLEARING LAND OF BRUSH AND STUMPS

By GEORGE R. BOYD, *Assistant Chief, Bureau of Agricultural Engineering*

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INTRODUCTION

AS FAR BACK as history goes some part of the world's population has been engaged in clearing up new land and putting it into cultivation. It has been said that it takes three generations to make a self-sustaining farm out of cut-over land. Moreover, cleared lands are sometimes abandoned, and must be recleared when again needed for crop production; so that land clearing is a problem in our oldest farming regions as well as in the newest settlements. The stumps left by the original or virgin growth still remain in many sections, and the stumps of the second and even third growth make the land-clearing problem a continuing one in almost all agricultural regions. Clearing up land for the plow is a matter requiring hard work, patience, experience, and usually the expenditure of a considerable amount of money.

It is impossible to give any figures of value as to the comparative cost of removing stumps by the various methods described, or any figures of the average or usual cost of stump removal. There are so many different things which affect the cost of stump removal, that costs vary between wide limits. Even when the comparison is made with the stump as the unit, rather than the acre, so many variations are encountered as to render the comparative figures valueless for other lands, or for the same lands at other times. It has been thought that the volume of wood removed would be a good basis of comparison but experiments show that there is so much variation in root shapes and holding power, even among stumps of the same size and species, that the comparative figures are almost valueless. Furthermore, any cost figures are apt to be grossly misleading for the reason that the most profitable kind of land clearing is that which is done with farm labor and equipment at odd times when no other productive work can be done, and the value of this labor is

hard to determine. In general the value of anything is what it will bring upon the market at the time it is available. Generally, the labor and equipment used in crop production on the farm are available for land clearing for only short periods, possibly a few hours at odd intervals, and there is very little outside demand or market for such intermittent labor. It is unfair to charge the land-clearing operation with $1 per hour for the use of a tractor when the tractor is used only for short periods when there is nothing else for it to do on the farm and when it would otherwise be idle. The same reasoning applies to the use of labor, whether it be that of the owner himself, or labor hired by the month or day.

NEED FOR CLEARING LAND

It is axiomatic that no farmer, either landlord or tenant, can make all the money he should make until he gets his fields in the best possible condition to produce crops at a low cost. No one who has held the handles of a plow in a stump field will deny that the

FIG. 1.—The cultivation of such land is expensive

cultivation of a crop among stumps is an expensive undertaking. A stump and its roots cause a great deal of lost time and broken equipment, occupy valuable space which should be yielding profitable crops instead of producing weeds to foul the entire field, and harboring injurious insects. Raising a crop on lands such as shown in Figure 1 is very expensive on account of the area lost to production and the high cost of cultivating the crop. Experiments carried on in Georgia show that, under the same conditions, it takes as long to plow 7 acres of stump field as it does to plow 9 acres of cleared land, so that the cost of plowing stump land is about one-fourth more than the cost of plowing cleared land. Fourteen plow points were found in and around the roots of a lightwood stump in Mississippi. These plow points cost about $1 each, and the stump was blasted out at a cost of 30 cents. Under favorable conditions a field can be more cheaply cultivated by plowing two rows at a time instead of one, and motor-drawn implements do economical work, but the most enthusiastic advocate of these modern, cost-saving, devices has never called a stump field a favorable condition for their operation.

There is a surprisingly large number of farmers in cut-over areas who have little or no chance to make money farming. These farmers are not confined to any one section or to any group of States. They should be interested in clearing land; in fact, they must clear land before their farms can become profitable, for until a farm is largely self-sustaining it can not be profitable. Until the farmer has the minimum acreage of cleared land necessary for his particular farm, he must bend every energy toward increasing his cleared acres so that his farm will become a self-sustaining, economical unit.

Although the disadvantages pertaining to the stump field and to the underdeveloped farm are always present, they are especially disastrous during "hard times" when the prices of farm products are low. At such times it is necessary, in order to make a profit, that every cultivated acre, and the farm as a whole, be in a condition to produce the largest possible crop at small cost. Clearing operations take considerable time for their completion, so that the landowner can not wait until a time of high prices arrives in order to get his land in shape to produce a maximum crop to sell at a high price. It follows, then, that land-clearing work, during times of depression, should be carried forward to completion as rapidly as can be done economically.

On most farms there are too many days when no productive labor is possible, and this is particularly true on underdeveloped and understocked farms. Wherever such a condition exists, land clearing gives employment for labor which would otherwise be lost, for it can be economically and effectively done at odd times during intervals when farm labor is not required for crop production. The landowner does not have to wait until he sells his farm to obtain a valuable return from this labor, as he will receive a yearly return in increased crops and in decreased cost of production.

Farmers will realize, of course, that there is some land which should not be cleared, because it will be more profitable if used for other purposes than agriculture.

DISPOSAL OF THE BRUSH

The first step in the preparation of cut-over land for cultivation is the removal of the fallen logs and brush. The fallen logs may be piled and burned, or they may be hauled off, while the undergrowth may be disposed of by grazing, by cutting and burning, or by plowing under. The principal factor in determining which method should be used is the length of time the owner is willing to wait before putting the land in cultivation.

GRAZING

Grazing is theoretically an economical way to clear land of brush, and undoubtedly close grazing has a great effect in reducing the cost of removing the stumps at the end of the pasturing period. Goats, sheep, and cattle are the animals most frequently used for this purpose. Goats are natural browsers, and there is no vegetation they will eat in preference to leaves and twigs, but in practice it has been found better to pasture cattle on the tract to eat up the grass, if it has been seeded, before turning the goats into it. Sheep are the next best browsers, but must be more closely pastured than

goats so that they will be forced to eat the bushes. In the cut-over lands of the upper peninsula of Michigan one ewe and one lamb will thrive on 1 acre of cut-over land during the open months and will keep down most of the sprouts. With either sheep or goats on large areas it is necessary to fence the land into small sections, concentrating the animals on each section for a short time until it has been browsed clean, then moving them to another section, then back to the first one, and so on.

Where grazing is depended upon to remove the underbrush it is usually necessary to cut such of the brush as is too high for the animals to reach. Such work should be done as early in the stage of the operation as possible. The cut brush and trees may be piled with the fallen logs and burned, or they may be left to decay, but when this is done they should be left as they fall and not piled up, as brush in piles generally does not rot as readily as when scattered on the ground. A growth of grass aids greatly in keeping down the suckers and sprouts and hastens the decay of fallen brush, but affords more feed for the stock, so that the standing brush is not eaten so quickly. It is advisable to go over the land at frequent intervals and cut down the growth which may be avoided or neglected by the stock in grazing.

The following method of pasturing is followed with considerable success in southeastern Missouri: In the summer or early fall all of the small trees, brush, and undergrowth are cut down and left where they fall. In December a 4-part mixture of grass seed, made up of timothy, orchard grass, red top, and alsike, is sown by hand. The next spring, after the grass has a good start, cattle are turned into the field. One acre will furnish pasture for two head of cattle, but for short periods or in exceptional seasons five head per acre can be pastured. The remaining timber is cut at convenient times, the merchantable timber and firewood hauled off, and the remainder left to decay. The cattle in feeding will break down the dead tops and the thickly growing grasses hasten the decay of all of the wood on the ground as well as of the stumps. In the early fall of the fourth year the cattle are taken out of the field and the grass is allowed to grow as high as it will before frost. In the winter, after frost has killed the grass, and during a dry time, the grass is set on fire. This fire is usually hot enough to burn completely all of the brush and down logs and partially consume the stumps. The stumps are then removed and the field is ready for plowing.

The pasturing of cut-over lands not only keeps the brush down but it reduces very materially the cost of stump removal. The trampling of the earth around the stumps as the cattle graze about them compacts and solidifies the soil and seems to work it away from the lateral roots of the stump, so that where land has been heavily pastured for some years the lateral-rooted stumps appear to be sitting on top of the ground. The 18-acre field of the experiment station farm at Chatham, Mich., which was originally cut-over land, was burned over, then seeded to grass and heavily pastured with sheep for seven years, and finally cleared of stumps and prepared for plowing at a cost of $19.98 per acre, while an adjoining tract of land, similar in all respects to the 18-acre field except that it was never burned, seeded, or pastured, was prepared for plowing at the same time as

the first field at a cost of from $115 to $125 per acre. This large saving is due in part to the burning and in part to the seeding and pasturing.

The practical advantages of pasturing with the main purpose of removing the brush are somewhat questionable. It requires that a considerable sum be invested in stock, and this investment is subject to all the ordinary vicissitudes of the livestock business with its possibilities of loss as well as of gain, and it is necessary in order that the brush shall be consumed to underfeed the stock, which increases the risk of losing on them. Considered as a means of keeping down the brush and also making easier the stump removal, seeding and moderately heavy pasturing is to be recommended when it is not required to cultivate the land for some three or four years.

CUTTING AND BURNING

The most common method of brush disposal is to cut, pile, and burn it. This method gets rid of the brush quickly, so that it will

FIG. 2.—A log pile should be compact and narrow, with the logs lying parallel and should be of good height

not interfere with the immediate cultivation of the land. Down logs, dead tops, and unmerchantable timber are worked up and removed or piled and burned as a part of the brushing operation.

It is a common belief that brush cut in the summer or early fall is not apt to sprout again, but investigations have demonstrated that there will always be some second and even third growth, regardless of when the brush is cut. To insure killing the growth it is necessary generally to go over the field at intervals and cut down the new growth. A good deal of brush is cut in the winter, because other farm work is not so pressing at that time and more labor is available.

The tools needed are few, but they should be in good working order. An ax, a brush scythe, or bush hook are about all that is needed for cutting the brush. For handling the logs a team, a chain about 15 feet long, a 30-foot length of one-half inch cable, and a crosscut saw are required.

The best piles of brush and logs are high and rather narrow, as shown in Figure 2. Piling in small piles, fairly high, with the logs

lying parallel is cheaper and better than making large piles, since the latter require additional labor and if the pile is too large, the fire may become so intense as to injure the fertility of the underlying soil. Logs and stumps should be burned in separate piles, as much more compact piles can be made in this way. In piling logs which can not be readily handled, a team, cable, and two timber skids may be used to advantage. The pile is started by passing a cable end under the log to be moved and hooking it to the log which is to be the center piece of the pile; the team, hitched to the other end of the cable, rolls the log up to the pile by means of this rolling hitch. It is good practice to put two or more crosspieces under log piles to provide air circulation when the pile is drying out and a draft when it is burning. Sometimes the brush is piled in windrows, which saves moving it through any considerable distance, but the windrows do not always burn up completely. Such windrows should extend in the direction of the prevailing wind in order to get a good burn. Very large logs are most easily burned in place after splitting their ends with explosives.

As a rule standing trees should be cut down before the brush is cut. It is generally better, especially where the trees are thick, to cut the trees and later remove the stump than it is to remove both tree and stump in one operation. Although it is somewhat easier to

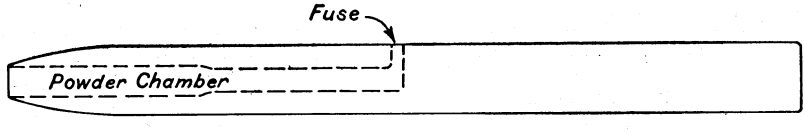

FIG. 3.—Splitting gun

pull a tree with a stump puller than it is to pull the green stump on account of the greater leverage which may be obtained by fastening the pulling cable higher on the tree than is possible on the stump, and though it takes but little more explosive to blast a tree than a green stump, in thick woods the fallen trees occupy so much ground space as to greatly increase the difficulty and cost of the operation.

In this brushing operation, any wood which is valuable for firewood or other use, should be removed from the field.[1] In splitting logs a splitting gun can be used to good advantage, especially for the large logs of the West. It consists of a pointed steel cylinder, hollow for half of its length, about 1½ inches in diameter and 18 inches long. Figure 3 is a detailed drawing of this patented device. A small charge of black powder is loaded into the pointed end of the gun, the latter is driven into the end of the log, and the powder ignited. A very small charge of powder will split a large log into pieces which can be easily handled by one man. The gun should be driven into the center of the log, or into solid wood, and knots, rotten spots, and cracks should be avoided. The same results may be ob-

[1] See "Measuring and Marketing Farm Timber," Farmers' Bul. 1210, U. S. Dept. Agr., also "Utilizing Poles and Timber in Farm Building," Ext. Bul. 24, Mich. Agr. Col., East Lansing, Mich.

tained by placing a small charge of explosive in a hole bored in the end of the log, tamping the charge in place and firing it.

In some of the hardwood sections of the South the general custom is to cut and burn the brush, deaden the trees, and put the land in cultivation, allowing the deadened trees to remain until they become so weakened by decay that they are blown down, and later are piled and burned. The stump is not removed until it becomes so rotten that it can be easily grubbed out. As it may take anywhere from 6 to 10 years for the stump to decay, and as the farming operations during all of this time are carried on under great difficulties, it is doubtful whether this method is truly economical, although it requires less expenditure of labor and money than would be the case if the trees were removed. Unless the dead standing trunks can be burned in place, as is sometimes done, it costs almost as much to remove them after they decay and fall as when they are green. Leaving the deadened trunk in place will not hasten the decay of the stump or make its removal cheaper.

Burning standing and live brush is of great value in destroying the brush and also in reducing the cost of stump removal. Fire in a cut-over country is always dangerous, and such a fire should be started only after complete and detailed arrangements for controlling it have been made. In many States it is necessary to procure a permit from the local authorities before a woods fire can be started, and there are certain seasons when such permits can not be obtained. A large percentage of the devastating forest fires in cut-over sections originate in land-clearing fires, so that the necessity for great care and watchfulness and of strict compliance with the law should be appreciated by everyone.

Tables 1, 2, and 3 give the comparative amounts of work required per acre in brushing, piling, and burning on two tracts of land in Minnesota, one having been burned over and the other unburned, also the labor required to remove the brush and the explosives required for blasting the stumps.[2]

TABLE 1.—*Work required per acre for brushing, piling, and burning brush on burned and unburned land in Minnesota*

Operation	Green timber		Burned timber		Saving in man labor due to burning
	Man hours	*Horse hours*	*Man hours*	*Horse hours*	*Per cent*
Brushing	63.3	----------	38	----------	40
Felling, trimming timber	80.5	----------	67.5	----------	16.1
Burning brush	9.9	----------	14	----------	41.4
Miscellaneous operations, skidding logs, poles, etc.	65	37.5	35.6	37.8	45.2
Total	218.7	37.5	155.1	37.8	----------

[2] From Bul. 220, Agr. Exp. Sta., Univ. of Minn., "The Effects of Forest Fires on Land Clearing and Crop Production."

TABLE 2.—*Comparative labor units per acre required in disposing of stumps in Minnesota*

Item	Green unburned		Green burned		Dry unburned		Dry burned	
	Man hours	*Horse hours*	*Man hours*	*Horse hours*	*Man hours*	*Horse hours*	*Man hours*	*Horse hours*
Blasting	30.8		7.1		7.7		2.3	
Piling refuse material	13		5.2	6.3	14.4	28.8	1.7	1.9
Pulling, piling small stumps	0		25.9	25.8	17.4	34.8	22.1	21.8
Pulling, piling after blasting	35	69.5	22.2	22.6	44.3	88.5	18	16.7
Burning	3.6		2.9		1.5		2.9	
Total	82.4	69.5	63.3	54.7	85.3	152.1	47	40.4

TABLE 3.—*Explosives and materials used per acre in blasting out the stumps in Minnesota*

Item	Green unburned area	Green burned area	Dry unburned area	Dry burned area
Dynamite, pounds	171	62.9	41	14.4
Caps, number	211	86	57	29
Fuse, feet	313	150	92	46

Very little detailed information is available as to the effects of forest and brush fires upon the fertility of the soils. It is known that such fires will add to the productivity of peat and muck soils, while it is likely that injurious effects are sometimes suffered by other soil types when used for certain crops. Minnesota Station Bulletin 220 says:

> Comparing crop production on the burned virgin soil (upland clay) with production on like soil unburned, sunflowers produced equally well or better; hay about as good; oats and potatoes distinctly less. Clover catches remarkably well in the ash.

In eastern North Carolina large areas of swamp land have been drained and are prepared for cultivation by burning the brush. All of the merchantable timber consisting of original growth of pine, cypress, gum, juniper, maple, and poplar has been cut out but the remaining unmerchantable timber and underbrush is very thick. The soils vary from heavy black loams to peat or muck and generally there is a layer, several inches in thickness, of turfy, vegetable matter on top of the ground. For several years past, the approved method of getting this land into cultivation has been as follows: In the late summer or early fall all of the growth is cut down and allowed to lie where it falls. This growth is so thick and rank that when it is cut it often forms a continuous mat, sometimes 6 feet thick, over the entire field. With labor at $1.50 per day, the cost of cutting down the brush is from $8 to $10 per acre. During May of the following spring the brush is set on fire. A satisfactory burn is one which destroys all of the brush, a good portion of the logs and stumps, and all of the turf. While the ground is still hot from the fire, corn is planted by hand among the remaining logs and stumps. Figure 4 shows such a burned-over field. If a sufficiently good fire has been obtained, few weeds will appear and no cultivation will be

necessary. When the corn is ripe it is picked and carried in sacks to the edges of the field, or roads may be cut through the down logs so that the corn can be hauled out of the field. During the winter, the down logs and loose stumps are piled and burned. This program is repeated for four years before the field is plowed. Each year more weeds appear, more hoeing has to be done to keep them down but each year more logs, roots, and stumps are removed, thus giving more space for planting corn, and making harvesting easier. The fourth year finds the ground sufficiently free of débris to allow of rough plowing with a disk plow and the crop is then raised in the usual manner. For a number of years roots and pieces of stumps will be turned up after each plowing so that piling and burning or hauling wood out of the field is necessary until the field is entirely clean. It is claimed that under the conditions in this section, the crop raised each year during the four preparatory years before plowing will be from 30 to 40 bushels of corn per acre, and that the costs of preparing, planting, cultivating, and harvesting the crop will be between $15 and $30 per acre per year. Such a method of land clearing can be economically followed only where there is an abundance of cheap labor. The success of the method is also largely dependent upon the thoroughness of the initial burn and it is not always possible to secure a good burn.

Some people who have tried the above method advocate the following variation of the plan: The timber is cut and burned as above, but the land is allowed to grow up to weeds for four years. In the fall of the fourth year, the weeds and new brush are cut, the stumps and down logs piled so that all can be burned off and the field plowed the next spring. It is claimed that the rank growth of weeds keeps the sunlight from drying out the logs, brush, and stumps and so hasten their decay; that this method preserves more of the fertility of the soil; and that the cost of the entire operation will be less than the net cost where a crop is raised among the partially burned logs and stumps. However, this method has not been given a thorough trial as yet so that it is not definitely known that it has any advantages over the older method.

In the Delta section of Mississippi where the growth is largely gum with some oak, hickory, and maple, the following plan is used: After the merchantable timber has been cut, the remaining trees and brush which are usually dense and of heavy growth, are cut down in the spring after the leaves are out. This work is usually let out by contract and with labor at $1.50 per day usually costs about $10 per acre. The next fall, after the weeds have been killed by frost, the entire field is burned over. The logs remaining from this fire are pulled together by a log skidder, piled and burned. This work usually costs about $12 per acre depending on the success attained with the original fire. The next step is the gathering of the unburned tree tops, underbrush, and débris. A 2-horse hay rake is used for this work which is hard on the rake but does gather up the loose material quite cheaply. Raking, piling, and burning this brush costs about $12 per acre, but this also depends on the results of the first burn. The stumps are left in place to decay which they will do in from one to eight years depending on the kind and size of stumps and the extent to which they have been burned. After the

first plowing the field is again raked over to collect the roots which were brought up by the plow.

In the arid sections of the Western States, the principle growth which must be removed prior to cultivation, consists of greasewood, sagebrush, mesquite, manzanita, chapparal, and other similar growth. Under some conditions of climate or fertility of soil, some of these shrubs approach trees in size and in such case they may be removed by any of the methods herein described for removing stumps and trees. Where they do not exceed 5 to 6 feet in height they may be railed, piled, and burned. The railing is done by hitching two or more 2-horse teams to the ends of a railroad rail, a heavy log, or a piece of timber with a steel cutting edge, and dragging it across the field to break off the bushes. The field is usually gone over twice but in opposite directions. It is most easily done when the ground is frozen. The stumps which remain are then grubbed up, or left

FIG. 4.—An eastern North Carolina field where the growth has been cut down and burned. The first crop of corn has just been planted

to be plowed up, and the brush is raked into windrows and burned. A brush rake may be made of a 6-inch timber, 12 feet long, by boring 2-inch holes through the timber, 10 inches apart, and inserting in each a wooden tooth about 3 feet long. The rake is then fastened by two timbers to the rear of a wagon to which a team is hitched.

In the Eastern States there are a number of trees which are very hard to destroy on account of peculiar root systems and a strong, persistent capacity for reproducing themselves. Sassafras roots strike perpendicularly into the ground for approximately 8 to 16 inches, then turn at right angles, rarely both ways, and pursue a horizontal course for about the same distance, when they split into numerous lateral feeder roots. The usual custom of cutting these roots off several inches below the ground serves only as a temporary expedient. The most satisfactory method of dealing with sassafras is to pull it out. Any clamp device, adjusted to a stout handle 5 to

6 feet long in such a manner as to give a strong leverage, will answer. The sassafras may be exterminated in one grubbing if the root is followed and cut beyond where it makes the angle, but this method is laborious. Constant and careful plowing, if maintained for several years, will gradually exterminate this bush but due regard for the condition of the soil will usually not permit such continuous plowing.

Persimmon and locust are very similar to sassafras and should be treated in the same way. The locust roots are a little nearer the surface, more numerous, attenuated, and tenacious than the other two mentioned. Alder should be cut off in August at or below the crown, left where they fall, and burned the following spring.

PLOWING

In some places where the stumps are few and far apart it is possible to plow the brush under and immediately put the land in crop. All trees over 2 or 3 inches in diameter, or more than 6 or 8 feet high, should be cut down and all stumps more than 6 inches in diameter should be removed before plowing is attempted.

There is a great variety of kinds and sizes of plows being used for this work, depending in part on the growth and the soil, and in part on the owner's opinion of the results obtained with the various makes of plows. Tractors are used for motive power because, although it would be possible to hitch enough horses onto the plow to pull it, they would not be as effective in breaking down the brush and small trees as is the tractor. The size of the tractor required depends on the power which it will be called upon to furnish. The smaller ones seem to give satisfaction where the work is within their pulling range. For heavy brush, the tractor should be strong in all its parts, the driving wheels should be equipped with extension rims and strong lugs, and it should have a large bottom clearance in order to pass readily over small stumps, débris, and stones. Some operators prefer to hitch the tractor to the plow with a chain about 10 feet long to give the plow greater flexibility, while others prefer a rigid, but adjustable, attachment so that the plow can be backed up when it gets wedged under a stump. The plows and coulters are of many different designs, but a single-bottom plow, from 20 to 24 inches wide, with a landside about 5½ feet long and 6 inches in width for large plows, and some form of standing coulter, seem to be the most popular. It is important that there be from 20 to 26 inches of clearance at the throat of a plow so that it will not be necessary to stop too frequently to clear the plow of brush and débris. The division of agricultural engineering of the University of Wisconsin has developed a brush plow with a throat clearance of 26 inches, which also has an offset in its beam so that the plow bottom is some 8 inches on the right side of the beam. This permits the space directly in front of and above the plow to remain relatively free so that most of the brush is caught and turned under by the rolling action of the furrow slice. A standing cutter, the upper end of which curves backward and to the right, was also designed to further prevent choking. This plow is shown in Figure 5.

A compilation of the returns to a questionnaire sent out to Minnesota farmers gives the following information as to the equipment used for plowing under brush in that State [3]:

Average drawbar horsepower of tractors		15.25
Average size of cut, inches		27.50
Average depth of breaking, inches		6.30
Average clearance of plow, inches		21.00
Average cost for fuel, oil, and labor per 10-hour day:		
Gasoline or kerosene	$5.27	
Oil and grease	1.39	
Labor, at 40 cents per hour	9.00	
Total		$15.66
Average cost per acre		4.24

The same report also says that the best time for plowing under brush is June, July and, possibly, August; that where brush has

FIG. 5.—Brush plow developed by the agricultural engineering department of the University of Wisconsin. The plowshare is offset 8 inches to the right of the beam to prevent choking with brush

been plowed under the land can be plowed a second time within two or three years after the first breaking; that more satisfactory work can be done when the ground is comparatively dry than when it is very wet; that after plowing the field is usually disked and sown to flax, hay, or grain; and that the crops grown for the first two years may equal those raised under normal methods of cultivation if all conditions are favorable.

There are some especially large and heavy plows made for this purpose which will plow 15 or 18 inches deep, but they are very expensive to operate and in some soils such deep plowing is not advantageous.

Where the conditions are favorable for plowing brush under the operating cost is undoubtedly less than the contract price of cutting, piling, and burning the brush. However, the cost of a plowing outfit is great, the plowing season is short and there is little other employ-

[3] Bul. 208, Agr. Eng. Div., Univ. of Minn., "Investigations in Stump and Stone Removal."

ment about a farm for such heavy equipment, so that this method of brush disposal is not economical for the farmer who desires to put only a few acres into cultivation in any one year.

Furthermore, when the brush is thick and heavy, the plowed surface is usually very rough and uneven, so much so that for several years plowing is difficult. If the brush is well covered it will generally rot rapidly, although at least one case is on record where the farmer had to dig up and pull out most of the brush when he tried to plow the field the first year following brush plowing. Usually enough brush and roots are left uncovered and exposed to the air so that they will not readily decay, to interfere, to a marked degree, with plowing for several years. Where brush plowing is done it is generally best to seed the tract and keep it in hay or pasture for three or four years.

In parts of several Southern States the scrub or saw palmetto is the principal undergrowth. This plant has a strong horizontal root which grows along or under the surface of the ground, and from this root an immense number of vertical feeder roots extend down into the soil. Formerly the palmetto was grubbed out by hand at a cost of from $75 to $150 per acre, but usually it can be plowed under by a heavy breaking plow. When the horizontal roots are more than 3 inches in diameter and are present in considerable numbers it is almost impossible to turn them under with the ordinary plow. A plow has been used with some success for this purpose which has a vertical cutting edge like a heavy standing coulter beneath the beam. At its lower end, about 4 inches below the ground, there are two horizontal knives 18 inches long extending at an angle of 45° in both directions. After this plow has cut off the feeder roots the palmetto can be easily pulled by hand and thrown into wagons to be hauled off and burned. With a small tractor about 2 acres of palmettos can be cut off in a day, and with a large tractor about 3 acres can be done in the same time. The manufacturers claim that heavy palmetto land can be cleared by means of this plow for about $20 per acre.

STUMP REMOVAL

GRUBBING

The earliest and most primitive method of stump removal, that of hand grubbing, is still used extensively in spite of the fact that it is very hard and tedious work. It is such laborious work that men can not be hired for this purpose so long as other easier jobs are to be had. For small stumps up to 6 or 8 inches in diameter it is generally the most effective and economical method of removal. As the size of the stump increases the economy of this method tends to decrease, but even on large stumps, where labor is cheap, the costs are not excessive. A South Carolina planter says that during the winter of 1921–22 he paid out over $400 for grubbing stumps at a cost of 10 cents per stump, but that two years earlier he could not have contracted this work for $2 per stump, as men would not do such work at any price during prosperous times. In the summer of 1922 the contract price for grubbing stumps in the Mississippi Delta was 25 cents per stump. In southwestern Texas labor is or has been so plentiful that grubbing out mesquite has been generally contracted for at a price of $15 per acre.

The tools required for grubbing are an ax, grub hoe or mattock, and a shovel. The advantages of grubbing out stumps are that it requires no investment in tools or equipment, it can be used equally well on thick or scattered, green or dead, rotten or solid stumps, and that it makes a clean job of removing the roots. The disadvantages are that it is very slow and laborious, for large numbers of stumps it requires either many men or a long time, it leaves the stump and roots in such shape that the large ones are hard to handle and dispose of, and where labor has to be hired at high rates, it is expensive. Although other methods of removal may be quicker and easier, it should be borne in mind that unless the labor so saved can be put to some profitable use, nothing has been gained by saving time. Large numbers of stumps are being removed by farm labor during intervals when there is no other profitable farm work to be done, and, under such conditions, the grubbing method should receive careful consideration.

BURNING

Fire, one of the oldest methods of destroying stumps, is still used to good advantage under many conditions. Although it is a comparatively simple matter to build a fire around a stump which will consume it, it is extremely difficult to burn the stump roots to a depth where they will not interfere with the cultivation of the field. The usual minimum depth required so as to be beyond any probable plowing depth, is 18 inches, since the ground about the stump is generally higher than the general surface, and because there will be considerable settlement in the ground when the stump is removed.

To obtain a good fire, the amount of heat present should be confined and conserved as much as possible and the air supply should be limited to just what is required for combustion. Stumps are burned with free or open draft, by char-pitting, and by devices for securing forced draft.

Occasionally it is possible to build a fire on the outside of a stump which will burn so readily as to destroy most of the roots, but usually it is necessary to get the fire into the center of the stump, where little heat will be lost by radiation, in order to burn the roots. With the taprooted, pine stumps of the South, which seldom exceed 30 inches in diameter, the general method of burning is to dig a hole, 15 or 18 inches deep and about a foot wide, on one side of the stump, down along the taproot, and then to bore a hole from the surface of the ground on the other side of the stump into the bottom of the dug hole. This hole should be about 2 inches in diameter, for smaller holes sometimes become choked with soot. A fire is started with brush in the bottom of the dug hole, and as the draft through the bored hole draws the fire into the stump, the whole stump will soon be blazing. A small quantity of brush may be piled around the burning stump to increase the draft and heat, but if too much brush is used it will keep the air away from the fire and the outside of the stump will become charred so that it will not burn completely. It is best to have only a small fire and to keep it going by frequent attention. It takes from 24 to 36 hours to burn a dry stump, and one man can keep about 75 stumps burning if they are not too widely scattered. Some burners watch their fires throughout the

night, but if only a few stumps are to be burned and the fires are started early in the morning only one rebuilding at night is required. Both stumps and ground must be dry to obtain good results, so this work can be done only when the weather conditions are right. A heavy rain may put out the fires, and when this occurs they are very hard to start again.

When this method is used on the large stumps of the West, two or more holes are bored into the stump. One hole is bored down the center of the stump to a depth of a foot below the ground surface and a second hole, started at or below the ground level and piercing one of the large roots, is bored so as to intersect the first hole near its lower end. The fire is started at the junction of the two holes with a hot iron, a glowing coal, or a blow torch. A hand bellows is very useful in getting a blaze started.

FIG. 6.—Gasoline-engine-driven auger used for boring holes in stumps to facilitate burning

These bore holes may be made either by hand or with a power-driven auger. As the holes are usually of considerable length it is a very tiresome task to bore them by hand and takes considerable time but, on the other hand, power-driven augers are expensive and their purchase is not justified unless a large amount of work is to be done. Some of these power augers are driven by their own power units, whereas others are made as attachments for different makes of tractors. Figure 6 shows a type of gasoline-engine-driven power auger. They range in price from $100 to $500.

In some localities the practice of blasting a stump just hard enough to split it as shown in Figure 7, is the first step in the burning operation. This practice can be followed with stumps, either with or without taproots, and it saves the expense of boring the holes, but generally the center of the stump burns out and leaves

a number of snags sticking up around the outside which can only be kept afire by continually piling on brush.

In order to have a good fire it is necessary that the burning and heat-generating parts should be close together all of the time so that no great amount of heat is lost by radiation. A method which produces this condition around the roots, where it is so greatly needed, is to saw the stump off just above the ground, the top is lifted from 2 to 4 inches and small stones placed between the two parts to preserve this distance. As the fire, which is started in the center of the stump, continues to burn, the force of gravity keeps the top always close enough to the base to reflect the heat from the more inflammable top down toward the roots which is a great help in burning them out.

The char-pitting method of destroying stumps is an adaptation of the methods used in making charcoal and consists of building a fire at the base of the stump and so inclosing it that only enough air to support limited combustion is admitted to the fire, and a great

FIG. 7.—A green, white-oak stump split with dynamite. It will be ready to burn in two or three months

part of the heat of combustion is retained within the stump. A fire of kindling wood is started between two roots or by encircling the stump with a fire. The latter method takes more kindling but makes a better and quicker fire. The bark should be cut away from the stump where the fire is to be placed, preferably some weeks before starting the fire, so that the stump may dry out as much as possible. The earth should be dug away from the base and roots of the stump so that the fire may burn underneath them. After the kindling wood is in place it may be covered with ferns or leaves and a thin layer of earth placed over it, except at the place where the fire is is to be started. A light coating of 3 or 4 inches of earth should be placed over the kindling, and the kindling should not be over 18 or 24 inches high. As the wood burns down, the fire will break through the dirt in places, and it is then necessary to apply more dirt to cover it. As the burning progresses more dirt should be shoved over the fire from that which has been in contact with it, and fresh dirt should be placed on the outer edge of the earth bank.

In case the fire burns above where the dirt is piled, it should be put out so as to confine the fire, as far as possible, to the base of the stump. It is necessary that the fire be covered at all times and never allowed to burn into an open blaze, for when it does so much heat is lost and so much air gets to the fire that the formation of charcoal ceases in a very short time. When the fire gets into the roots, they must also be kept covered with earth. Figure 8 shows a stump being burned by this method.

A char-pit fire on a large stump may burn for a month or two, and during all this time it must be carefully watched to make sure that the fire does not break through the earth seal. Ordinarily two or three times per day is often enough to visit the burning stump, and it is possible for one man to tend a large number after the fires get well started. Clay soils are the only ones which pack and bake satisfactorily. Resinous stumps, with taproots, are more easily handled than any others, and this method is limited to stumps of considerable size. It is possible to char-pit wet stumps and also to do this work in wet weather, but the results are more apt to be satisfactory when stumps, roots, and ground are dry.[4]

FIG. 8.—A stump being burned by the char-pitting method

Successful char-pitting depends upon keeping a great mass of hot charcoal in the heart of the root crown from which the fire burns slowly downward, drying the wet wood ahead of it. This is a difficult matter to accomplish as the fire is started on the outside of the stump and burns toward the interior, and a great amount of care must be taken in regulating the rate of burning. Then, too, the fire is difficult to start, and if it should go out, it is very hard to get it going again. A number of devices, ranging from simple plates and draft tubes to stoves which cover the entire stump, have been designed to make it possible to start the fire in the middle of the stump or to permit greater control of the rate of burning.

One of these devices, which has been used extensively in the West, consists of a furnace, two hoods, a long draft pipe, two short draft pipes, and several lengths of ordinary stove pipe, this outfit costing about $30. The method of operation is to place the furnace on one side of the stump over the end of the long draft pipe. A length of stovepipe is fitted to the top of the furnace, and the furnace is banked with earth, making a tight seal between the furnace and the stump, as shown in Figure 9. A fire is then started in the furnace, and as

[4] More detailed information as to simple char-pitting is given in Bul. 62, Series 1, of the Extension Service, Wash. State Col., Pullman, Wash., "Destroying Stumps by Char-pitting Methods."

it grows the furnace door is closed with earth and air is drawn in through the draft pipe with considerable force. One end of this draft pipe, lying in a bed of coals, is red hot and throws a blast of flame against the base of the stump, thus starting a fire hole. As the fire burns into the stump the draft pipe is pushed forward gradually until the hole is burned through the stump, which may not occur for a day or two with large stumps. When the fire hole is through the stump, the hood, with stovepipe attached, is placed over the opening and banked in with earth. The long draft pipe and furnace are removed; a short draft pipe is put in the furnace end of the hole and banked over. As soon as the stump is thoroughly on fire and producing a good lot of charcoal, the hood and draft pipe are removed and the entire stump banked in with earth, and from this point on the treatment is the same as in simple char-pitting.[5] As in char-pitting, the stump must be carefully watched until it is entirely consumed, which may take a month or more.

FIG. 9.—A stump burner and some of the accessories, showing the method of setting the furnace directly against the stump

A large number of stove or hood burners have been used for burning stumps usually consisting of a sheet-iron hood which completely covers the stump and so secures a continuous and accurate control of the draft and confines the heat of combustion. Where stumps and ground are dry such hoods are often successful in burning the roots out completely. However, they have never been used extensively.

From time to time there have appeared on the market various devices for burning stumps by forcing a strong draft of fire to pass through the stump or down into the roots. Some do this by producing a vacuum which draws the fire into and through the stump at a rapid rate, and others blow strong drafts upon the fire, thus causing the same effects. Such machines burned the stump very rapidly, but this rapid burning of the stump did not allow sufficient time for the flames to dry out and heat up the roots so that they might burn also. As the destruction of the roots is of vital importance, such forced-draft burners have been generally unsuccessful.

Were it possible to destroy a stump and its roots by burning, and many claim that it is possible, this would be an ideal way to dispose of them, for this method requires no large investment of money, and destroys the stump in place which does away with piling and burn-

[5] Detailed description and directions for use of the Zyzzet burner are given in Bul. 195, Oreg. Agr. Col., Corvallis, Oreg., "Stump Land Reclamation in Oregon."

ing and filling up the hole left in the ground. The general consensus of opinion is, however, that it is only under the best of conditions that any method of burning will destroy the roots below plow depth. Irrespective of the size of the stump, it is generally true that it costs more to remove the roots left by a poorly burned stump than it would have cost to remove the stump and roots together by other means. The same trouble is found in all of these burning methods; namely, that they require so much close and careful attention, and the exercise of so much judgment, that it is almost impossible to get labor which will be painstaking and intelligent enough to successfully use these methods. However, all of these methods of burning are extensively used and each method has many strong advocates.

PULLING

There are many mechanical devices for the use of power in pulling stumps ranging from the straight pull of a team to huge machines with immense pulling power.

The simplest puller is a chain with a hook on one end and a team of horses on the other. The hook is fastened to, or around, one of the main roots of the stump, placed across the top of the stump which acts as a fulcrum, thus giving a leverage which increases the pulling power of the team. Stumps of considerable size can be pulled in this way if sufficient grubbing and chopping off of roots be done to lighten the pull required until it comes within the capacity of the team. The pulling power of a tractor can be used in the same way and somewhat larger stumps can be pulled than can be moved with a team. Such work is hard on either team or tractor, and it is generally better to increase the power available than to attempt to pull large stumps with such a simple outfit. This can be done by using a longer chain, a rope, or a wire cable in place of the short chain, and threading it through one or more pulleys or blocks. A wire cable about five-eighths inch in diameter is the best, for a rope is usually too weak to stand the continued strain, and a chain is heavy and unwieldly. By using one pulley the power can be doubled, and two pulleys will treble the power; but the time required to pull the stump is increased, and it also takes more time to attach and fasten the cables and get ready to pull.

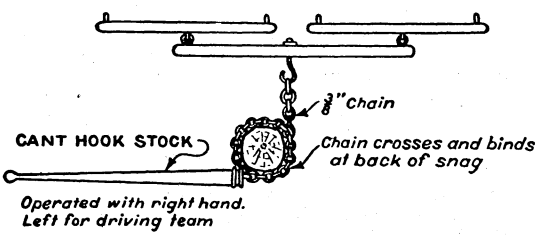

FIG. 10.—Chain whip

A simple device, called a "twister" is used with fair success in some localities. It is a pole beam about 20 feet long of some tough wood, with a chain and hook on one end. The chain is wrapped around the stump and made fast with the hook, and a team, fastened to the free end of the beam, walks around the stump, thus twisting it until the roots pull out or are broken off.

A device called a "whip," illustrated in Figure 10, has been developed by the agricultural engineering division of the Michigan Agricultural College for pulling brush, snags, and small stumps. It con-

sists of a cant-hook handle, to the large end of which a three-eighths inch chain, 2½ feet long, has been fastened. The free end of the chain is fastened to the whippletrees of a team; the operator wraps the chain around the stump so that it is crossed and binds on the side away from the team, and holding the end of the cant hook in his right hand so as to keep the chain rigidly in place he drives the team ahead with the reins in his left hand. As soon as the stump is pulled the chain can be readily disengaged. On small stumps and standing brush this device works very rapidly and efficiently.

For somewhat larger stumps a "mallet stump puller," shown in Figure 11, can be cheaply made with the tools available on any farm. This large mallet has a head of cedar or other light wood 18 inches in diameter and 30 inches long, and the handle is of hickory or other tough wood about 6 inches in diameter and 6 feet long. A pull chain

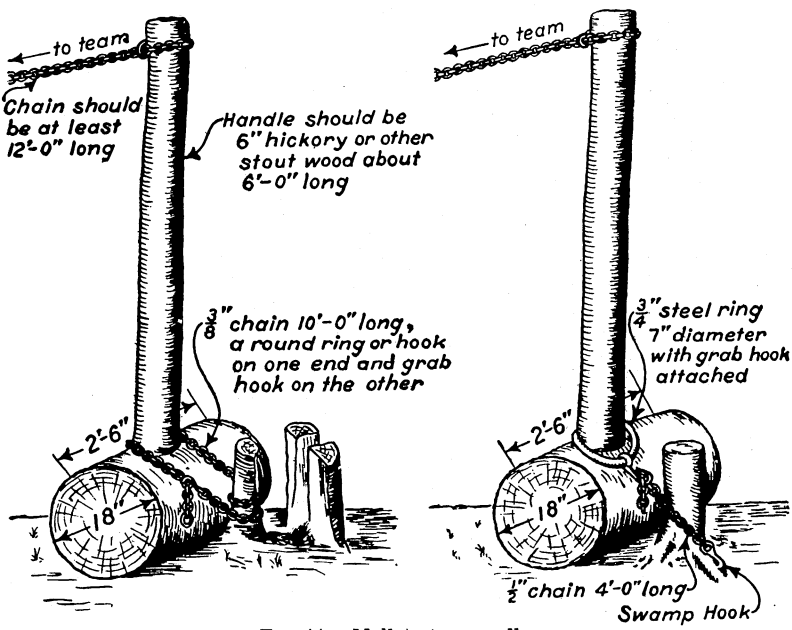

FIG. 11.—Mallet stump puller

12 feet long is fastened to the end of the handle. It is operated by placing the head of the mallet as close to the stump as possible with the handle in an upright position against the stump. A heavy chain with a "corner bind" or "fid hook" attachment is placed around the stump as low as possible and then around the handle where it enters the log; it is essential that this chain be as tight as possible, as the greatest leverage is obtained when there is no slack in the chain. When the handle is pulled down to a horizontal position by the team the stump is turned up on the mallet head. The pulling power of the team is increased about six times with this device. Very little strain comes on the mallet head, so the lightest obtainable wood should be used for it, but the handle should be made of tough, strong wood. The 6-inch hole can be made in the mallet head by cutting or burning, but the best way is to bore several small holes within

the area of the proposed hole and then with a chisel chip out the walls between the small holes. An iron bolt through the mallet head to keep the handle from coming out, an eye-bolt at the top of the handle, and some sheet metal at the lower end of the handle to prevent the chain from wearing into it are all good additions, but are not essential.

There are a number of types of manufactured or commercial stump pullers differing in design, in the source of the motive power, and in size. The primary requisites of all types are, (1) enough power must be developed to do the required work; (2) each machine must be so constructed that it can be operated with safety; and (3) it must be capable of being moved about easily or it must be equipped to pull a large number of stumps from one place.

All of these pullers, except the large machines, must be anchored to a substantial stump. Practically all of the small machines have an anchor cable which is placed around the anchor stump and allows the puller to swing around with the direction of the pull line, thus permitting the pulling of all the stumps within reach of the pull line from one anchor stump. The "pull line" is fastened to the stump which is to be pulled with a "choker hook." There are several kinds of devices called "take ups," equipped with a short cable and choker hook, which can be attached to the pull line at any point for pulling stumps close to the machine or for pulling more than one stump at a time. There are "cluster cables" which can be attached to the end of the pull line for pulling a group of stumps with one pull. Pulleys, to which are attached short cables with choker hooks for anchoring, can be introduced to increase the power of the pull. "Root hooks" are made for pulling roots, snags, or stumps which have been cut too low to allow the pull line to be fastened to them. Figure 12 shows a type of root hook which has been used with much success in Michigan. Most pullers are arranged for two speeds. The slow speed, having the most power, is used for heavy pulling, while the high speed is used for pulling small stumps and dragging the pulled stumps to a pile. With some designs the speed may be changed while the pull is being made, if desired. Safety is obtained by various automatic locking devices which reduce the liability of accident in case any part breaks.

The economical operation of a stump puller and its accessories is a matter which requires both experience and judgment. Efficient operation requires speed, and that means that the operator must be able to plan his work ahead and use his equipment so that as soon as the strain is taken off by one stump coming out of the ground, it is taken up by another stump. It is largely because of the many niceties of adjustment in the use of accessories and the ability to know precisely in what order to pull the stumps, that one crew will pull twice as many stumps in a day as another.

The motive power of the pullers may be hand power, horsepower, power taken off tractors, or from steam or gasoline-driven engines. The hand-power pullers are of two types, the clutch type and the drum type. In the clutch puller the pull line is gripped by a steel clutch and pulled in by means of a lever worked by hand. In the drum pullers the cable is wound around a drum which is turned by a hand lever. The power of the hand pullers is increased where

necessary by means of pulleys so that large and heavy stumps can be pulled, but their speed is much slower than pullers which have more power. Of the two types, the drum has a greater power within itself, but it is possible to clear a greater area from one anchor stump with the clutch type; the slack cable is more easily disposed of, and the hitches are somewhat easier to make by reason of the lighter cable used. Hand pullers are adapted for work where the stumps are small, or widely scattered, where the number to be pulled is not large, or where other sources of power are not available or can not be used, as in swampy or very rough ground. Two men make the best size of crew under average conditions although all of the work can be done by one man if necessary. Either type requires hard and tedious labor, so much so that a man can hardly operate one continuously. Hand pullers weigh from 100 to 400 pounds, the heavier

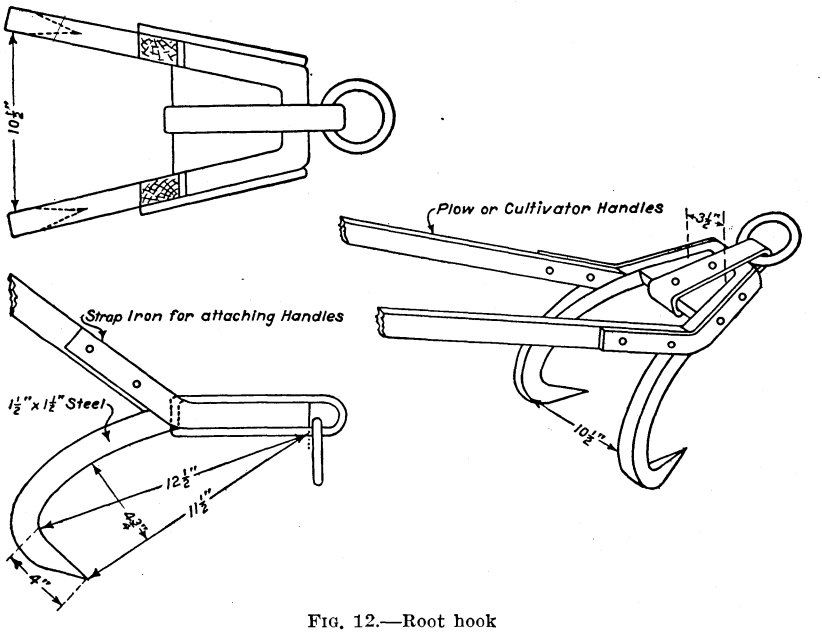

FIG. 12.—Root hook

ones being mounted on small trucks or wheels. Including the necessary accessories, hand pullers can be purchased at from $100 to $400.

The principal difference in the design of horsepower pullers lies in the direction of the pull exerted on the stump, which may be either vertical or horizontal. Some years ago the tripod puller, which exerted a vertical pull on the stump, was extensively used, but for the last several years very few of them have been sold in this country. The vertical puller had great power and exerted it in the line of least resistance of the stump, but the machine was hard to move on account of its shape and necessarily heavy construction; it had to be moved for each stump pulled, and its operation was slow. The pullers in use at present exert their pull in a horizontal direction by means of a cable wrapped around a vertical drum, turned by means of a team work-

ing at the end of a sweep. Having more power in the team and a greater leverage in the sweep than is possible in the hand pullers, the horsepower machines have much greater power and so can pull stumps of considerable size without introducing cables and slowing up the speed of pulling. The power of the team is usually multiplied 25 to 30 times with a simple pull line and this power may be doubled or trebled by introducing one or two pulleys.

Most makes of horsepower pullers are equipped with long anchor cables, which allow the team to pass between the anchor stump and the machine, thus avoiding the necessity of cutting off the top of the anchor stump to allow the sweep to pass over it. Figure 13 shows a horsepower puller in operation.

It is not necessary or economical to buy a machine which will pull the largest stumps in the field, as the heavy cables will have to be used in pulling the small stumps as well as the large ones. The entire operation will be cheapened by getting a size of puller which

FIG. 13.—Pulling stumps with horsepower puller

will readily pull about 60 per cent of the stumps and by using explosives to loosen up the larger ones until they can be pulled by the machine.

If the puller is stopped and the strain held just as the stump is being turned over on its side, a man with a grub hoe can knock off a good deal of earth which clings to the roots so that it will fall back into the hole. Using explosives to loosen the stumps makes the roots come out free from dirt.

It is easier to pull stumps in light sandy soils than in heavier clays, and generally less power is required when the soil is moist than when it is dry. Green stumps, of course, are much harder to pull than dead ones.

The most economical size of crew of experienced men is three men with a team and driver, while for inexperienced men two men, team, and driver will be better, for if the crew is without experience the third man will be more of a hindrance than a help.

The following hints for a beginner with a horsepower outfit are very good:[6]

1. Set puller on level ground, higher than the stumps to be pulled, if possible, so cable will be low enough for the team to pass over. Select stout anchor stump. With axe cut notches for anchor cable close to the ground.
2. Crack any large stumps with small charges of dynamite if they are too large to handle or if they will bring up too much soil. Place charges shallow and close to wood of stump for splitting.
3. Fasten cable on stump so no sharp bends are made in cable to weaken or bend it. Hook as high as possible on stump to be pulled and thus get leverage.
4. Use grub hoe on earth clinging to roots just as stump comes from the ground while the soil is over the hole. Stop team and knock off soil. It pays to get it off.
5. If the cable seems to be coming off the stump before it is pulled, throw a chain around an exposed root and hook to cable ahead of take-up. A short cable with hooks on each end works well here, too. This scheme is also good with the root-plow (root-hook).
6. Dig a place to tie chain around blind stumps and small roots. Use grub hoe to make a good place to hook the root plow.
7. A block of wood, or piece of stump, thrown in front of the top of the stump as it falls after being pulled will make it easier to remove cable from pulled stump. The other take-up can be put on an exposed root and stump tipped over again to remove cable which sometimes gets fastened.
8. Grease puller carefully. Grease old cable with oil-soaked waste or rags. Grease will soon soak in and cable will be smoothed up. Grease cable when not in use.

Horsepower pullers weigh from 100 to 1,500 pounds and vary in price from $75 to $700 or more, depending on the size of the machine and the amount of equipment furnished. An outfit for medium work would probably include, besides the stump puller, 100 feet of pull-line cable, the size depending on the size of the machine, but probably ¾-inch, two power pulleys, three take-ups, a long anchor cable, one or two extension cables for lengthening the pull line, and a root hook. Such an outfit costs about $300. Other tools required are an ax, grub hoe, crowbar, and shovel.

Horsepower pullers can pull almost any stump, especially with the aid of explosives in loosening up the largest ones, but their economical use is limited to situations where the number of stumps is large enough to justify the investment of a considerable amount of money. The most economical work can be done where the stumps are thick and uniformly of a size which can be pulled by the machine without the aid of pulleys, and where a high type of labor is available to take charge of its operation.

In recent years there have been developed several different pullers designed to use the power of farm tractors for pulling stumps. In general, the machines consist of an attachment for transferring the power of the driving shaft of the tractor, through a series of gears, to the shaft of a horizontal drum around which the pull line is wound. Some types have two drums and two speeds, as shown in Figure 14. A transverse runner or shoe is generally put under the tractor base which allows the machine to skid around the anchor stump following the direction of the pull line. Pulleys may be used in the pull line to double or treble the power when necessary as in

[6] From Cir. No. 148, Ext. Serv., Col. of Agr., University of Wisconsin, "Keep the Stump Puller Working."

the horsepower pullers. These attachments are variously priced but probably about $500 is the average cost of them.

There are several types of large machines which use the power developed by their own steam, gas, or kerosene engines. These develop a great deal of power so that stumps can be pulled rapidly without using pulleys and can work over a large area from one set-up. They are generally pilers as well as pullers since the most of them are equipped to pull the stump and also drag it into a central pile. The most commonly used of these large machines is what is called the "donkey engine"—an adaptation of logging machinery and methods to stump removal. It consists of a hoisting engine, either steam or gas, with at least two drums. The equipment on the larger machines consists of 1,000 feet of 1⅛-inch pull-line cable, 2,000 feet of ⅝-inch haul-back cable, four 1-inch guy cables, two 10-inch blocks for gin pole, four 8-inch blocks for the haul-back

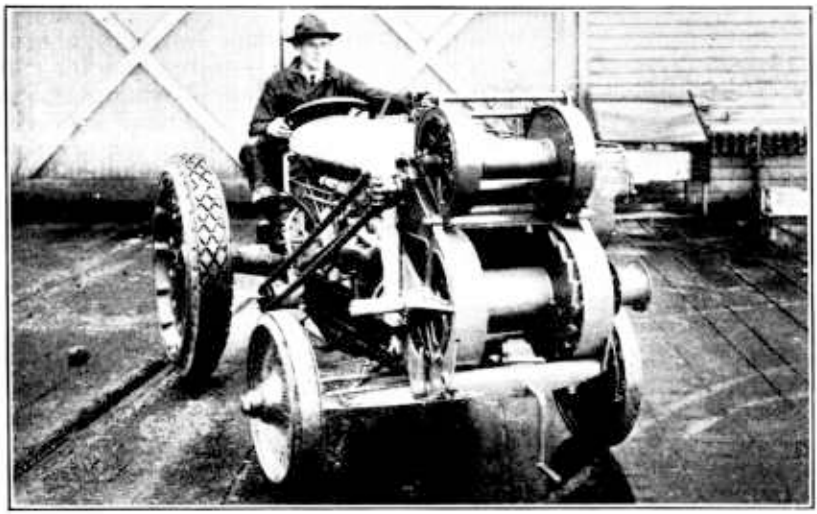

FIG. 14.—Type of puller attachment for tractor

line, lead lines, chokers, etc. A large machine with such equipment can clear stumps from a 10-acre tract at one set-up. The engine is usually placed at the center of the area and a gin pole, sometimes 100 feet high, is erected a short distance in front of it. The pull line and the haul-back line are passed through blocks near the top of the gin pole, and the haul-back line is passed around a part of the land in front of the engine, passing through pulleys at the corners of the area and is then fastened to the end of the pull line. A stump is fastened to the pull line by a short piece of cable, pulled in to and upon the pile, the haul-back cable running out freely, and when the stump has been dropped onto the pile, the haul-back cable is pulled in which draws the pull line out again. Explosives are usually employed to split and loosen the larger stumps. Smaller machines with less power, covering less area from one position and following the same plan of work have been used but it appears that, in this type of machine, the larger ones are more economical than small units. Such machines, which may cost anywhere

from $1,000 to $12,000, can only be considered where the stumps are large and numerous and where the area to be cleared is sufficiently great to warrant a large investment. The principal field of usefulness of this type of machine, so far developed, is the Pacific Northwest.

In general, stump pullers are adapted for work under a wide variety of conditions, there being types of pullers suitable for almost every kind of stump removal. The advantages of a stump puller are that it removes all of the stump roots which would interfere with cultivation, and that, with experienced crews, its cost of operation is comparatively small. Its disadvantages are that the first cost is high; that it can not well handle rotten stumps; that it sometimes leaves large holes in the ground which must be filled before the ground can be cultivated; and that the pulled stump is hard to handle after it is on top of the ground, so that its further disposal is often quite an expensive matter.

BLASTING

Explosives are widely used for blasting stumps entirely out of the ground, for loosening up large stumps before pulling, and for splitting stumps which have been pulled. The details of stump blasting and the use of explosives for this purpose are described in United States Department of Agriculture Circular 191. (Now out of print.)

It is the writer's opinion, based upon an observation of stump-blasting methods in all the agricultural States, that the average man wastes about one-third of the explosive he uses in blasting stumps. A loud, sharp report, stump pieces thrown high in the air, and a large crater left in the ground, are sure evidences of wasted explosives. To obtain the best results with a minimum of explosives, the charge should be well down in the ground, under the center of resistance of the stump, and the borehole above the charge should be well and thoroughly tamped with moist clay.

The electric method of firing is to be preferred to the use of the cap and fuse because of its greater safety and because much better work can be done, especially with large lateral-rooted stumps.

The advantages of blasting stumps are: That this method requires little investment of capital; that the amount of labor required is small; that the stumps are thrown out free of earth and split up so that they are easily handled; that it can be used in any kind of weather, and that it is equally available for few or many stumps widely scattered or close together.

The disadvantages of using explosives are that the explosives cost money and that sometimes large holes are left in the ground after the stump has been blasted out. There is, too, an element of danger always and inseparably connected with the use of explosives. This danger, however, is unduly magnified in the minds of many, for experience shows that the average farmer can blast stumps with safety if he will use the proper tools and follow implicitly the directions which are inclosed in each box of explosives. The danger is not in the explosive but in the man who uses it.

DECAY

In some sections the stumps are left in the cultivated fields until they become so rotten that they can be knocked over with an ax. A number of stumps, such as the oak, ash, hickory, and gum, will rot so that they can be easily removed in from 5 to 10 years; but there

are others, notably the pine, fir, cypress, poplar, and cedar, which will not decay to an appreciable extent for many years.

The process of decay can be hastened by introducing poison into the circulatory sap system of the living tree. There are a number of poisons, in varying degrees of strengths, which may be used. One which gives good results is composed of 1 pound of white powdered arsenic, 2 pounds of lye, and 2 gallons of water. To prepare the poison, first, make a paste of the arsenic by adding a small amount of water. Put the lye into 1 gallon of water slowly, stirring as the lye is added. The dissolving lye heats the water; and when all the lye has been dissolved, and while the water is still hot, add the arsenic paste, a little at a time, stirring until it is all dissolved; then add the second gallon of water. If it is desired to mark the trees which have been poisoned, add 1 pound of whiting to the solution. Two gallons of poison will be sufficient for about 30 trees averaging 15 inches in diameter. The arsenic in small lots costs from 30 to 50 cents per pound and the lye about 15 cents per pound.

To apply the poison cut a continuous ring of gashes around the tree about 2 feet above the ground, penetrating through the first and second barks and into the sapwood. The cuts should be made so that they will retain the poison rather than permit it to run down the outside of the bark, as is shown in Figure 15. Pour the poison into the cuts, using an old teakettle or coffee pot with a long spout for convenience in applying. The solution should be stirred frequently to prevent sedimentation. Three men can ring and poison about 200 trees per day. Utensils which have been used in preparing or applying the poison should be destroyed immediately after the work is completed to prevent their use for other purposes.

There are diverse opinions as to the best time of year to apply the poison. Some say in the spring when the sap is rising or in the summer while the sap is up in the tree, whereas others claim that the best results, especially as to killing sprouts and suckers, will be obtained in the late fall. Theoretically, the best time to apply the poison is in the spring, just about the time the buds are forming. The poison takes effect more quickly on bright, sunny days than on dark or rainy ones.

The poison will cause the leaves of the trees to wither and fade within a couple of weeks, and the process of decay then goes on quite rapidly in some species of trees and more slowly in others. In one case of 208 trees of various species poisoned in the spring, the trunks of 77 had fallen within 1 year; in another case of 46 trees, 27 had fallen within 15 months. It is probable that under favorable conditions the stumps of trees remaining two years after poisoning can be removed with small expense.

The poison recommended above seems to kill most species of trees, except pines and resinous woods, although the action is quicker with some species than with others. Records kept of the poisoning of various species, using a number of different poisons, show that nine months after poisoning the trees were affected in about the following order, hackberries, elms, oaks, ash, soft maple, willow, alder, persimmon, hickory, and pecan, the hickories and pecans showing the smallest proportions of deaths. It is possible that after a few more months most of these species would be dead, for in another case white

slippery and red elms, sweet gums, hackberries, ashes, redbuds, bowdoeks, and red locusts were all dead 15 months after poisoning. The wood of a poisoned tree is discolored and becomes soft and punky, so that it is of no value as lumber and makes poor fuel.

Poison cannot be used successfully on stumps. A stump has no complete circulatory sap system so that there is no way in which the poison can be circulated through a stump as it circulates through a tree. Some species of brush can be killed by spraying the poison solution on the leaves, although more than one application is sometimes necessary. In some cases, brush can be killed by cutting it and covering the freshly cut stubs with poison.

FIG. 15.—Gashes are cut entirely around the trunk of the tree to receive poison which hastens decay

Extreme care must be taken in handling this poison. The fumes given off during the mixing are deadly, and must not be inhaled. Cattle should be kept out of fields for a few days after poison has been used, as there is a possibility that they will lick the poison out of the cuts. Chemical analyses of the withered leaves show that cattle would not be harmed by eating the leaves of poisoned trees.

There are a number of commercial tree poisons on the market which are used in the same manner as given above, and with practically as good results. They can be purchased ready to apply or only require dilution with water.

The advantage of leaving the stump or tree in the field until it decays completely is that it decreases the first cost of the land-clearing operation. The disadvantage is that the presence of the

stump or tree in a cultivated field during the time required for it to decay so decreases the area of land available for crop and so increases the cost of cultivation that the first saving is usually more than counterbalanced. Where there is no money available for removing them it is better to poison the trees than to allow them to continue to grow, as the time required for decay is somewhat shortened by poisoning.

DISPOSAL OF THE STUMP

Not the least of the problems in clearing land is the disposal of the stump after it has been removed from the ground. Experience shows that it usually costs about as much in time and money to destroy the stump as it does to pull or blast it. Unless the stump can be removed from the field, it is better to leave it in the ground than on top of it.

The usual method of stump disposal is to pile and burn them, an operation which is not so simple as it sounds. It is first necessary

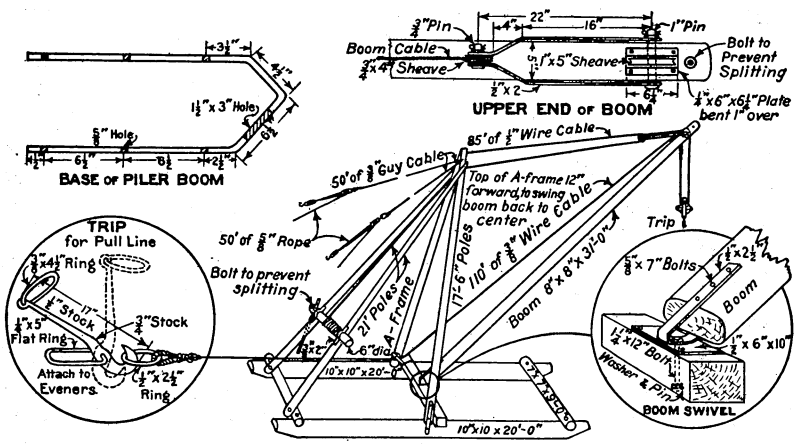

FIG. 16.—Conrath stump piler

to gather the stumps into piles, and where the stumps are small or have been well broken up by blasting this is usually done by dragging the pieces to the pile with a team. A small pile is started by rolling and skidding a number of stumps together and when the pile gets too high to roll the stumps on by hand, a long chain is thrown over the pile and the stumps are hitched so as to roll them up on the pile when a team pulls on the chain. A tractor may be used in place of the team for dragging and piling the stumps. More elaborate means may be necessary where the stumps are large and numerous, and lines drawn in by any of the various types of hoisting engines may be used for this purpose. The stumps may be lifted onto the pile by a cable reaved through a block at the top of a tree, gin pole, or portable derrick. Generally some form of gin pole is used on account of its cheapness and ease of handling. The Conrath piler (fig. 16), which has been used extensively in Wisconsin, requires very little blacksmithing and can be built cheaply. With any device for lifting stumps onto a pile, some kind of a trip to release the

stump at the proper time is desirable. The Frost trip (fig. 17), also developed in Wisconsin, gives very good satisfaction and can be cheaply made by a blacksmith.

Where large stumps have been pulled, they must generally be split with explosives in order that they may be easily handled, that the earth may be removed from the roots, and that a more compact pile can be built. The removal of the earth from the stump before piling is of especial importance, for oftentimes so much earth clings to the roots, as in the case of the tree shown in Figure 18, that it is impossible to move or burn it until the earth has been removed. One of the best methods of splitting a stump is to bore a 1½-inch hole into it just above the crown and inclined downward toward the center of the stump, deep enough so that the center of the charge will be just past the middle of the stump and so that there will be at least 8 inches of space left above the charge in the wood for the stemming, but, of course, not deep enough to approach too closely the opposite side of the stump. This method is shown in Figure 19. Some prefer to bore this hole in the top of the stump, at its center, directly toward the roots and about 18 inches deep. The power augers heretofore described may be used for boring these holes if they are available. Where no augers are at hand, a "mud-cap" charge, or "dobie shot" may be placed between two of the large roots where they join the stump.

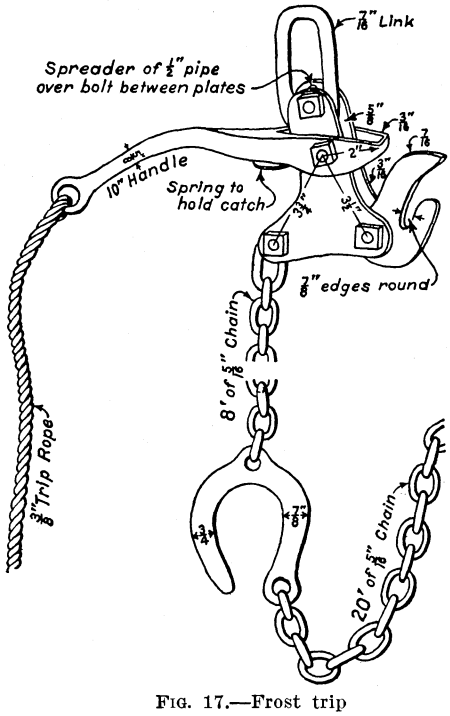

FIG. 17.—Frost trip

The piles should be made as compact as possible, small at the base with considerable height, rather than low and wide. They should not be too large, for the heat may be so intense as to injure the fertility of the ground underneath. The maximum size depends upon the kind of stumps burned, which largely influence the amount of heat thrown off, and the type of soil. Some authorities say that five large, resinous stumps will make a fire hot enough to appreciably injure some kinds of soil. It is very important that as much earth as possible be removed from the roots before piling them as the earth interferes to a marked extent with obtaining a good fire. With large piles some prefer to start the fire at the top of the pile rather than at the bottom as they say this method requires less work in obtaining a complete burn.

Stumps may be dragged from the field and dumped into ravines or gullies, or piled on ground too stony or rough for cultivation. The use of stumps for fences has happily almost disappeared. Such

fences were not only a blot upon the landscape but they occupied much valuable space which could not be cultivated or kept free from weeds.

The stumps may be dragged along the ground or they may be loaded onto a sled, stone-boat, or wagon. A sled which has been used extensively in Georgia is 4½ feet wide by 8 feet long. It is pulled alongside the stump, the roots on the side of the stump next to the sled are cut off and the stump rolled onto the sled.

Probably no one has watched the burning of a large stump pile without wondering if it were not possible to make some use of this wood instead of wastefully destroying it. A great many investigations of this problem have been made from many different angles but it appears that, at the present time, there is no profitable use

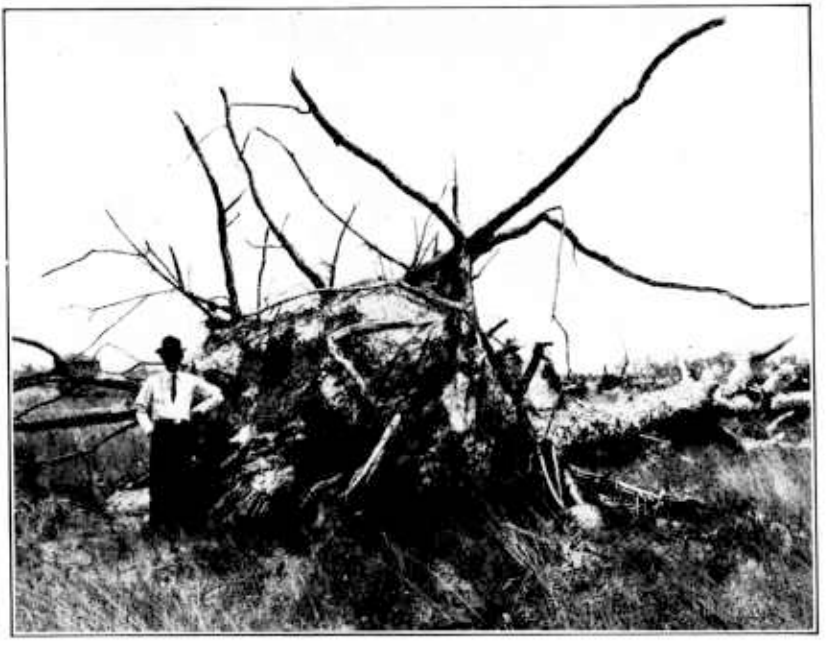

FIG. 18.—Slash pine, showing earth clinging to roots, one year after pulling

which can be made of the greater part of the stumps now being destroyed.

In some sections there is a sufficiently large demand for firewood to pay the cost of splitting up and delivering the stump wood. This is true in certain sections of the South where the fat lightwood stumps can often be sold for enough to pay the cost of their removal, but in most sections, especially where stumps are abundant, firewood is still so plentiful that there is no market for stump wood for this purpose.

It would seem to one unfamiliar with all the ramifications of the naval-stores industry that the resinous pine stumps could be distilled and the products profitably marketed, but investigation shows that generally such operations can not be profitably conducted at the

present time. It appears that the pine stumps of the North and West are not sufficiently rich in resinous oils to make them useful for this purpose now,[7] and that the profitable production of turpentine and its by-products is limited to the long-leaf pine stumps of the South. There are two different methods of obtaining valuable distillation products from long-leaf pine stumps—the steam-distillation process and the destructive process. The steam process manufactures wood turpentine, pine oil, and resin. It is essentially a large-scale operation and there are 10 large plants of this kind in various parts of the South. The destructive-distillation method is adaptable to either large or small plants, the large ones making wood turpentine, pine oil, acetic acid, tar, and charcoal, while the smaller ones generally carry their processes no further than a pine oil, which contains

FIG. 19.—Boring hole for explosive with which to split stump

all the liquid distillate, and charcoal. There are six large plants of this type and many small ones scattered throughout the South.

The destructive process is seemingly adapted to the owner of a few hundred acres of stump land who may wish to get out and distill his own stumps, but few operations of this kind have been successful, due largely to the limited market available for the products of such distillation. Numbers of research workers have been engaged in studying this problem and whenever some substance which can be sold in large quantities at a fair price is found in the distillate, the problem of disposing of the long-leaf pine stumps will be solved.

There is now some demand for stump wood in areas adjacent to the large plants. The prices obtainable depend largely upon the distance of the wood from the plant and the railroad facilities for

[7] U. S. Dept. Agr. Bul. 1093. "The Distillation of Stumpwood and Logging Waste of Western Yellow Pine." Out of print; may be consulted in libraries.

shipping it. One plant uses the stump wood from 50 acres of land each working-day, and there are several plants almost as large as this one, so that the total acreage required in a year, when the plants are running full time, has been estimated at 100,000 acres. The larger plants obtain the most of their wood by leasing stump lands at nominal figures and removing the stumps with their own forces. One disadvantage in leasing stump land to a distillery arises from the tendency to leave the taproot in place, owing to the expense involved in getting it out, so that the landowner often has to spend more money in removing the taproot than the disposal of the entire stump would have cost him. Such contracts should definitely specify that the taproot shall be removed to a minimum depth of 18 inches.

Other plants buy fat wood from the owners, some paying for it by the ton and others by the cord. The average weight of a cord of fat wood is about 3,300 pounds. Before the wood can be sold, it must be worked up into suitable sizes; the steam distillers will take pieces up to 8 by 8 inches by 4 feet, while the maximum size for destructive distillation is 4 by 4 inches by 4 feet. Where the stumps are blasted out they will generally be split into sufficiently small pieces by the blast and to make certain of this a rather faster explosive than might otherwise be used should be employed. Stumps 14 inches in diameter will yield about 400 pounds of fat wood. Usually there is as great a tonnage of fat wood in the fallen logs as there is in the stump wood. The prices paid for both are variable but probably average about $2 per ton for log wood and about $2.75 per ton for stump wood when delivered at a plant. An average acre in southern Georgia will yield about 8 tons of each, so that the value of both the log and stump wood is about $38 per acre, less the cost of delivery to a plant. Until a stump is 6 years old there is so much sapwood in it that it does not pay to distill it, but from that age on to at least 20 years, it does not deteriorate although each fire which burns over it destroys some of its value. There is generally a considerable number of stumps and logs on the land which are not rich enough to be sold for distillation but which must be removed before the land is finally cleared.

Detailed and extensive investigations have determined conclusively that under present conditions there is little profit in distilling any of the hardwoods or nonresinous conifers in order to produce wood alcohol, other chemicals, or charcoal.

Generally, then, it seems that it is necessary to destroy the stumps, as there is, at this time, no profitable use to which they can be put, and the space which they occupy is needed for the profitable production of crops.

SELECTION OF LAND-CLEARING METHOD

In brushing it is generally best, where there is no immediate necessity for cropping the land, to burn it over, cut down the remaining trees and brush, seed it to grass, and pasture heavily for two years or more. This treatment will not only destroy the greater part of the brush but will greatly lessen the cost of removing the stumps, while the grazing stock will bring in some valuable return during the period of pasturing. Where it is desired to begin the cultivation of

the land at once, the land should be burned over, the remaining brush and trees cut down, piled, and burned.

For stump removal, the conditions are more varied than for brushing, and consequently there is a greater number of situations which govern the choice of the method to be used. Undoubtedly the most important factor in the determination of the method is the fact that many of the farmers all over the country are without funds to invest in equipment for stump removal. To a man in this position it is immaterial how cheap a method which requires a heavy investment may be, as he, perforce, must use some method which comes within his means. In such a case, grubbing, the use of homemade pulling devices, burning, and blasting, are the only available methods. (Blasting is included in this list although it does require the investment of some money, for a man may very well be able to buy a hundred pounds of dynamite for use on the large stumps, where he would be unable to buy a stump puller.) A man in this situation would use grubbing, for this is the cheapest method of getting small stumps out, especially where slack-time labor is used, and as the size of the stumps increases, he will use his team or tractor and the homemade pullers in pulling, and with the very large stumps he will use explosives to split or blast them out entirely. He will use the burning method only for resinous stumps, in clay soils, and where labor is sufficiently careful and painstaking to insure the destruction of the roots.

The choice of methods for the removal of scattered stumps, either in cut-over areas or in cultivated fields, is limited generally to grubbing, pulling with teams, tractors, or light pullers, burning, or blasting, for the reason that so much time is lost in moving heavy equipment among widely scattered stumps that their operation is not economical.

The man who has only a small number of stumps to remove can not afford to invest heavily in equipment, so that he too must choose between the grub hoe, mallet puller, fire, and explosives.

There are doubtless many localities where types of power pullers can be rented for a nominal sum, and in such localities the use of the horsepower puller and heavier equipment might be advisable, where the amount of work would not justify its purchase.

Where large areas are to be cleared, all of the methods and equipment reviewed in this bulletin, as well as other heavy machinery which has not been described on account of its limited use, may be employed. The selection of the method in this case should be made only after a careful balancing of a large investment, and heavy operating costs with a large daily output, on the one hand, against a small investment, small operating costs, and small areas cleared daily, on the other.

In general stumps are most economically disposed of by piling and burning them. The methods of handling and piling will depend upon the size and number of stumps.

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